

CS 575/475

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Project #3

A Real Application Parallel Challenge

1. Tell what machine you ran this on

rabbit.engr.oregonstate.edu

2. Tell what operating system you were using

Linux OS on rabbit

3. Tell what compiler you used

GCC (GNU Compiler Collection)

g++ proj03.cpp -o proj03 -lm -fopenmp

4. Include the table of performance data.

	1	2	4	6	8
2	18.115	16.591	16.597	17.961	25.811
3	30.967	20.516	19.183	19.156	17.664
4	20.485	20.564	26.965	20.602	23.315
5	23.318	23.16	21.758	19.457	27.929
10	26.653	26.906	29.819	26.575	26.836
15	34.597	28.367	36.194	29.479	29.173
20	29.961	40.756	36.351	31.526	32.2
30	60.078	35.48	34.963	37.81	35.592
40	37.474	37.388	42.415	63.277	39.901
50	48.12	49.432	38.156	54.588	40.385

Thread	Capital	Megapersecond
1	2	18.115
1	3	30.967
1	4	20.485
1	5	23.318
1	10	26.653
1	15	34.597
1	20	29.961
1	30	60.078
1	40	37.474
1	50	48.12
2	2	16.591
2	3	20.516
2	4	20.564
2	5	23.16
2	10	26.906
2	15	28.367
2	20	40.756
2	30	35.48
2	40	37.388
2	50	49.432
4	2	16.597
4	3	19.183
4	4	26.965
4	5	21.758
4	10	29.819
4	15	36.194
4	20	36.351
4	30	34.963
4	40	42.415
4	50	38.156
6	2	17.961
6	3	19.156
6	4	20.602
6	5	19.457
6	10	26.575
6	15	29.479
6	20	31.526
6	30	37.81
6	40	63.277
6	50	54.588

8	2	25.811
8	3	17.664
8	4	23.315
8	5	27.929
8	10	26.836
8	15	29.173
8	20	32.2
8	30	35.592
8	40	39.901
8	50	40.385

5. Include a graph of performance vs. NUMT with the colored curves being NUMCAPITALS.

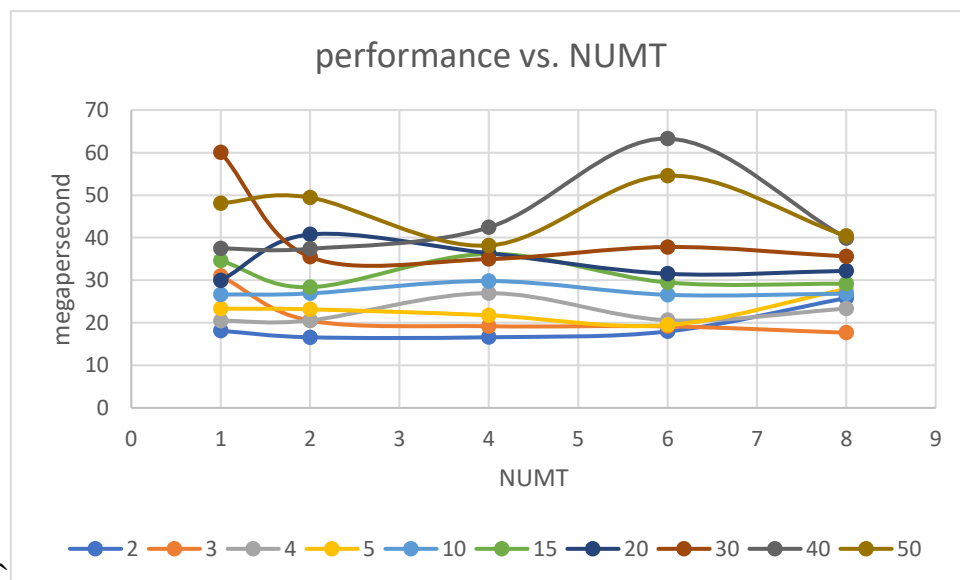


Figure 1

6. Include a graph of performance vs. NUMCAPITALS cities with the colored curves being NUMT.

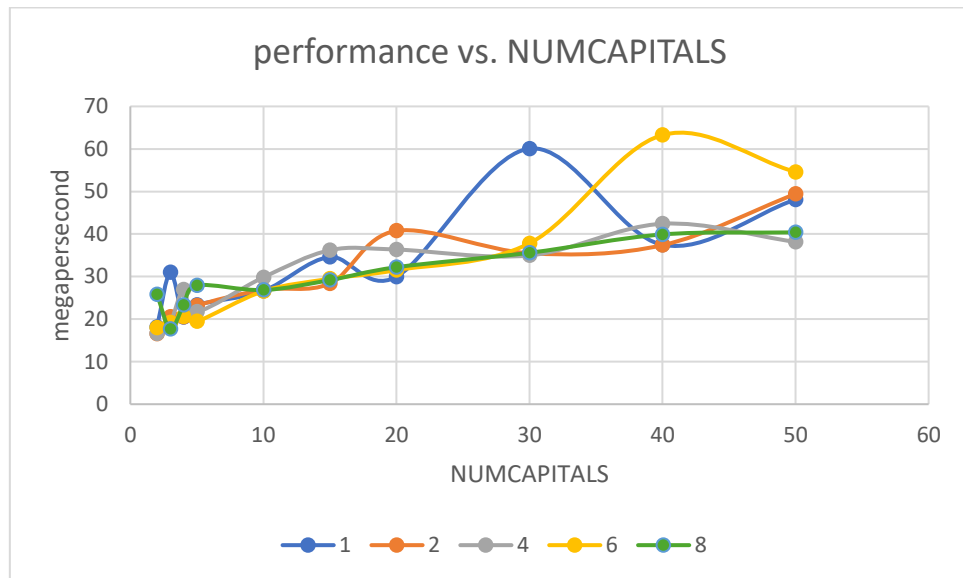


Figure 2

7. Tell us what you discovered by doing this. What patterns are you seeing in the graphs?

Figure 1 illustrates the relationship between different numbers of threads (NUMT) and performance. Each colored curve represents a different number of capitals (NUMCAPITALS). Overall, increasing the number of threads generally improves performance. When the number of threads is 2, the performance of NUMCAPITALS = 50 reaches its maximum peak. However, when the number of threads increases to 4, performance fluctuates, and the performance of some NUMCAPITALS drops significantly, such as NUMCAPITALS = 5 and NUMCAPITALS = 50. As the complexity of data grouping increases with NUMCAPITALS = 50, performance fluctuates noticeably. However, with NUMCAPITALS = 30 and 40 under 6 threads, the performance remains at a high level. This may be because when NUMCAPITALS = 30 and 40, the data is grouped more evenly, allowing each thread to receive sufficient tasks and reducing the impact of thread contention and cache contention.

Figure 2 shows the impact of different numbers of capitals (NUMCAPITALS) on performance. Each colored curve represents a different number of threads (NUMT). The overall trend shows that as NUMCAPITALS increases, performance gradually increasing but becomes

stable after a certain point. With 4 and 8 threads, performance rises relatively steadily. Comparing Figure 1, we can see that each NUMCAPITALS remains relatively stable with 4 and 8 threads. The performance of 1 thread fluctuates significantly. This is due to the lack of parallelism, as all computing tasks are handled by a single thread, failing to take full advantage of multi-core CPUs. The remaining curves are relatively flat. Generally speaking, when the number of threads is 4 or 8, performance stability is better. It can be inferred that these two thread counts maximize parallelism and reduce contention.

8.Extra Credit:

```
[huanchih@rabbit ~/cs575$] bash loop.bash
OpenMP is supported -- version = 201107
0: 85.82 , 36.04
0: 85.82 , 36.04 , Murfreesboro,TN
1: 116.27 , 37.16
1: 116.27 , 37.16 , LasVegas,NV
1 , 331 , 2 , 22.334
OpenMP is supported -- version = 201107
0: 77.42 , 39.58
0: 77.42 , 39.58 , Washington,DC
1: 90.98 , 33.99
1: 90.98 , 33.99 , Memphis,TN
2: 116.71 , 37.28
2: 116.71 , 37.28 , LasVegas,NV
1 , 331 , 3 , 23.595
OpenMP is supported -- version = 201107
0: 74.24 , 40.72
0: 74.24 , 40.72 , Newark,NJ
1: 83.91 , 35.14
1: 83.91 , 35.14 , Knoxville,TN
2: 98.01 , 35.00
2: 98.01 , 35.00 , OklahomaCity,OK
3: 118.27 , 37.15
3: 118.27 , 37.15 , Visalia,CA
```

0: 85.82	36.04		
0: 85.82	36.04	Murfreesboro	TN
1: 116.27	37.16		
1: 116.27	37.16	LasVegas	NV
1	331	2	18.115

0: 77.42	39.58		
0: 77.42	39.58	Washington	DC
1: 90.98	33.99		
1: 90.98	33.99	Memphis	TN
2: 116.71	37.28		
2: 116.71	37.28	LasVegas	NV
1	331	3	30.967
0: 74.24	40.72		
0: 74.24	40.72	Newark	NJ
1: 83.91	35.14		
1: 83.91	35.14	Knoxville	TN
2: 98.01	35		
2: 98.01	35	OklahomaCity	OK
3: 118.27	37.15		
3: 118.27	37.15	Visalia	CA
1	331	4	20.485
0: 74.24	40.72		
0: 74.24	40.72	Newark	NJ
1: 108.10	36.56		
1: 108.10	36.56	RioRancho	NM
2: 82.85	34.2		
2: 82.85	34.2	Athens	GA
3: 94.64	35.37		
3: 94.64	35.37	BrokenArrow	OK
4: 119.45	37.39		
4: 119.45	37.39	Clovis	CA
1	331	5	23.318
0: 74.10	40.73		
0: 74.10	40.73	JerseyCity	NJ
1: 92.01	41.15		

1: 92.01	41.15	CedarRapids	IA
2: 111.39	33.45		
2: 111.39	33.45	Mesa	AZ
3: 81.58	28.82		
3: 81.58	28.82	Orlando	FL
4: 120.86	45.93		
4: 120.86	45.93	Gresham	OR
5: 117.77	34.11		
5: 117.77	34.11	Pomona	CA
6: 96.70	31.77		
6: 96.70	31.77	Waco	TX
7: 106.77	39.74		
7: 106.77	39.74	Boulder	CO
8: 83.57	37.95		
8: 83.57	37.95	Lexington	KY
9: 121.65	37.98		
9: 121.65	37.98	Antioch	CA
1	331	10	26.653
0: 73.03	41.52		
0: 73.03	41.52	Waterbury	CT
1: 112.53	35.42		
1: 112.53	35.42	Peoria	AZ
2: 119.66	36.04		
2: 119.66	36.04	Visalia	CA
3: 96.97	31.62		
3: 96.97	31.62	Waco	TX
4: 120.86	45.93		
4: 120.86	45.93	Gresham	OR
5: 80.99	27.33		
5: 80.99	27.33	PortSt.Lucie	FL

6: 86.47	33.49		
6: 86.47	33.49	Birmingham	AL
7: 78.58	36		
7: 78.58	36	Raleigh	NC
8: 82.22	41.8		
8: 82.22	41.8	Cleveland	OH
9: 87.51	40.93		
9: 87.51	40.93	Joliet	IL
10: 94.56	40.89		
10: 94.56	40.89	DesMoines	IA
11: 105.34	38.45		
11: 105.34	38.45	ColoradoSprings	CO
12: 118.41	34.17		
12: 118.41	34.17	Burbank	CA
13: 117.47	33.72		
13: 117.47	33.72	Corona	CA
14: 121.80	38.07		
14: 121.80	38.07	Antioch	CA
1	331	15	34.597
0: 71.89	42.1		
0: 71.89	42.1	Worcester	MA
1: 121.03	47.58		
1: 121.03	47.58	Bellevue	WA
2: 120.46	39.63		
2: 120.46	39.63	Reno	NV
3: 96.22	29.13		
3: 96.22	29.13	SugarLand	TX
4: 88.08	41.5		
4: 88.08	41.5	Joliet	IL

5: 78.79	35.47		
5: 78.79	35.47	Cary	NC
6: 119.66	36.04		
6: 119.66	36.04	Visalia	CA
7: 97.41	33.42		
7: 97.41	33.42	Denton	TX
8: 85.75	32.61		
8: 85.75	32.61	Montgomery	AL
9: 117.65	34.02		
9: 117.65	34.02	Ontario	CA
10: 80.98	27.1		
10: 80.98	27.1	PortSt.Lucie	FL
11: 106.77	39.74		
11: 106.77	39.74	Boulder	CO
12: 75.05	40.63		
12: 75.05	40.63	Allentown	PA
13: 82.76	41.65		
13: 82.76	41.65	Dearborn	MI
14: 121.75	38.23		
14: 121.75	38.23	Antioch	CA
15: 111.39	33.45		
15: 111.39	33.45	Mesa	AZ
16: 86.22	36.62		
16: 86.22	36.62	Nashville	TN
17: 120.73	44.6		
17: 120.73	44.6	Bend	OR
18: 94.40	41.06		
18: 94.40	41.06	DesMoines	IA
19: 122.18	37.54		
19: 122.18	37.54	Hayward	CA

1	331	20	29.961
0: 74.50	40.78		
0: 74.50	40.78	Woodbridge	NJ
1: 121.67	37.41		
1: 121.67	37.41	SanJose	CA
2: 78.82	42.17		
2: 78.82	42.17	Buffalo	NY
3: 120.93	39.1		
3: 120.93	39.1	Roseville	CA
4: 94.48	44.87		
4: 94.48	44.87	Minneapolis	MN
5: 119.60	36.65		
5: 119.60	36.65	Clovis	CA
6: 105.18	39.06		
6: 105.18	39.06	ColoradoSprings	CO
7: 89.23	42.98		
7: 89.23	42.98	Madison	WI
8: 113.17	42.36		
8: 113.17	42.36	SaltLakeCity	UT
9: 80.98	27.1		
9: 80.98	27.1	PortSt.Lucie	FL
10: 73.10	41.67		
10: 73.10	41.67	Waterbury	CT
11: 86.03	32.56		
11: 86.03	32.56	Montgomery	AL
12: 76.62	37.67		
12: 76.62	37.67	NewportNews	VA
13: 122.87	38.09		
13: 122.87	38.09	SantaRosa	CA

14: 111.39	33.45		
14: 111.39	33.45	Mesa	AZ
15: 94.79	38.59		
15: 94.79	38.59	Olathe	KS
16: 88.97	41.07		
16: 88.97	41.07	Peoria	IL
17: 118.02	34		
17: 118.02	34	ElMonte	CA
18: 116.93	34.01		
18: 116.93	34.01	MorenoValley	CA
19: 97.95	32.87		
19: 97.95	32.87	FortWorth	TX
20: 119.26	34.53		
20: 119.26	34.53	Ventura	CA
21: 79.93	34.72		
21: 79.93	34.72	Concord	NC
22: 86.39	36.37		
22: 86.39	36.37	Nashville	TN
23: 71.21	42.29		
23: 71.21	42.29	Cambridge	MA
24: 121.03	47.58		
24: 121.03	47.58	Bellevue	WA
25: 94.57	30.38		
25: 94.57	30.38	Beaumont	TX
26: 122.58	45.04		
26: 122.58	45.04	Salem	OR
27: 98.17	27.57		
27: 98.17	27.57	CorpusChristi	TX
28: 84.14	41.3		
28: 84.14	41.3	Toledo	OH

29: 122.17	37.92		
29: 122.17	37.92	Berkeley	CA
1	331	30	60.078
0: 78.15	42.39		
0: 78.15	42.39	Buffalo	NY
1: 95.65	36.07		
1: 95.65	36.07	BrokenArrow	OK
2: 122.46	37.89		
2: 122.46	37.89	Richmond	CA
3: 122.26	47.55		
3: 122.26	47.55	Renton	WA
4: 119.60	36.65		
4: 119.60	36.65	Clovis	CA
5: 117.67	33.81		
5: 117.67	33.81	Anaheim	CA
6: 96.88	32.97		
6: 96.88	32.97	Carrollton	TX
7: 97.76	26.57		
7: 97.76	26.57	Edinburg	TX
8: 79.48	35.57		
8: 79.48	35.57	Greensboro	NC
9: 84.23	40.98		
9: 84.23	40.98	FortWayne	IN
10: 99.49	27.56		
10: 99.49	27.56	Laredo	TX
11: 82.36	27.69		
11: 82.36	27.69	St.Petersburg	FL
12: 113.32	38.49		
12: 113.32	38.49	St.George	UT
13: 76.62	37.67		

13: 76.62	37.67	NewportNews	VA
14: 94.47	41.29		
14: 94.47	41.29	DesMoines	IA
15: 87.60	34.06		
15: 87.60	34.06	Tuscaloosa	AL
16: 110.66	33.44		
16: 110.66	33.44	Mesa	AZ
17: 122.21	44.06		
17: 122.21	44.06	Bend	OR
18: 80.29	25.92		
18: 80.29	25.92	Hialeah	FL
19: 97.61	30.46		
19: 97.61	30.46	RoundRock	TX
20: 80.32	33.26		
20: 80.32	33.26	NorthCharleston	SC
21: 88.76	41.47		
21: 88.76	41.47	Aurora	IL
22: 82.75	30.16		
22: 82.75	30.16	Gainesville	FL
23: 84.31	33.96		
23: 84.31	33.96	SandySprings	GA
24: 74.35	40.58		
24: 74.35	40.58	Woodbridge	NJ
25: 80.26	27.01		
25: 80.26	27.01	WestPalmBeach	FL
26: 101.58	33.02		
26: 101.58	33.02	Lubbock	TX
27: 93.92	30.15		
27: 93.92	30.15	Beaumont	TX

28: 80.96	28.18		
28: 80.96	28.18	Orlando	FL
29: 81.61	32.68		
29: 81.61	32.68	Savannah	GA
30: 73.10	41.67		
30: 73.10	41.67	Waterbury	CT
31: 105.21	40.18		
31: 105.21	40.18	Boulder	CO
32: 122.73	45.43		
32: 122.73	45.43	Portland	OR
33: 119.03	34.54		
33: 119.03	34.54	Ventura	CA
34: 120.46	39.63		
34: 120.46	39.63	Reno	NV
35: 80.20	26.15		
35: 80.20	26.15	FortLauderdale	FL
36: 71.13	41.85		
36: 71.13	41.85	Brockton	MA
37: 116.77	45.22		
37: 116.77	45.22	Meridian	ID
38: 71.24	42.48		
38: 71.24	42.48	Cambridge	MA
39: 121.72	37.85		
39: 121.72	37.85	Antioch	CA
1	331	40	37.474
0: 74.08	40.68		
0: 74.08	40.68	JerseyCity	NJ
1: 98.10	26.77		
1: 98.10	26.77	Edinburg	TX
2: 83.90	39.64		

2: 83.90	39.64	Dayton	OH
3: 85.24	33.6		
3: 85.24	33.6	SouthFulton	GA
4: 85.45	36.84		
4: 85.45	36.84	Louisville	KY
5: 119.60	36.65		
5: 119.60	36.65	Clovis	CA
6: 77.31	36.38		
6: 77.31	36.38	NewportNews	VA
7: 119.04	35.35		
7: 119.04	35.35	Bakersfield	CA
8: 83.74	42.42		
8: 83.74	42.42	AnnArbor	MI
9: 82.42	28.83		
9: 82.42	28.83	Gainesville	FL
10: 80.43	34.46		
10: 80.43	34.46	Columbia	SC
11: 114.74	36.4		
11: 114.74	36.4	NorthLasVegas	NV
12: 85.94	40.5		
12: 85.94	40.5	Fishers	IN
13: 112.00	33.37		
13: 112.00	33.37	Tempe	AZ
14: 122.26	47.55		
14: 122.26	47.55	Renton	WA
15: 117.33	34.47		
15: 117.33	34.47	Victorville	CA
16: 117.44	34.03		
16: 117.44	34.03	JurupaValley	CA
17: 108.55	45.79		

17: 108.55	45.79	Billings	MT
18: 101.58	33.02		
18: 101.58	33.02	Lubbock	TX
19: 88.97	41.99		
19: 88.97	41.99	Rockford	IL
20: 81.06	41		
20: 81.06	41	Akron	OH
21: 91.08	31.55		
21: 91.08	31.55	BatonRouge	LA
22: 88.77	37.08		
22: 88.77	37.08	Clarksville	TN
23: 104.93	39.71		
23: 104.93	39.71	Denver	CO
24: 122.17	37.92		
24: 122.17	37.92	Berkeley	CA
25: 71.21	42.29		
25: 71.21	42.29	Cambridge	MA
26: 117.13	32.95		
26: 117.13	32.95	SanDiego	CA
27: 95.18	29.78		
27: 95.18	29.78	Pasadena	TX
28: 77.54	43.03		
28: 77.54	43.03	Rochester	NY
29: 76.90	39.01		
29: 76.90	39.01	Washington	DC
30: 94.34	44.32		
30: 94.34	44.32	Minneapolis	MN
31: 75.31	40.3		
31: 75.31	40.3	Philadelphia	PA
32: 116.40	43.6		

32: 116.40	43.6	Meridian	ID
33: 121.67	37.41		
33: 121.67	37.41	SanJose	CA
34: 97.61	30.46		
34: 97.61	30.46	RoundRock	TX
35: 95.04	38.65		
35: 95.04	38.65	Olathe	KS
36: 120.93	39.1		
36: 120.93	39.1	Roseville	CA
37: 111.98	40.69		
37: 111.98	40.69	WestValleyCity	UT
38: 73.03	41.77		
38: 73.03	41.77	Waterbury	CT
39: 111.65	40.25		
39: 111.65	40.25	Provo	UT
40: 117.17	33.58		
40: 117.17	33.58	Murrieta	CA
41: 117.33	47.67		
41: 117.33	47.67	Spokane	WA
42: 119.63	34.47		
42: 119.63	34.47	Ventura	CA
43: 106.64	33.64		
43: 106.64	33.64	LasCruces	NM
44: 80.40	26.36		
44: 80.40	26.36	CoralSprings	FL
45: 117.93	33.85		
45: 117.93	33.85	Fullerton	CA
46: 118.38	34.23		
46: 118.38	34.23	Burbank	CA
47: 96.94	33.22		

47: 96.94	33.22	Frisco	TX
48: 122.58	45.04		
48: 122.58	45.04	Salem	OR
49: 122.87	38.09		
49: 122.87	38.09	SantaRosa	CA
1	331	50	48.12
2	331	2	16.591
2	331	3	20.516
2	331	4	20.564
2	331	5	23.16
2	331	10	26.906
2	331	15	28.367
2	331	20	40.756
2	331	30	35.48
2	331	40	37.388
2	331	50	49.432
4	331	2	16.597
4	331	3	19.183
4	331	4	26.965
4	331	5	21.758
4	331	10	29.819
4	331	15	36.194
4	331	20	36.351
4	331	30	34.963
4	331	40	42.415
4	331	50	38.156
6	331	2	17.961
6	331	3	19.156
6	331	4	20.602
6	331	5	19.457
6	331	10	26.575
6	331	15	29.479
6	331	20	31.526
6	331	30	37.81
6	331	40	63.277
6	331	50	54.588
8	331	2	25.811
8	331	3	17.664
8	331	4	23.315

8	331	5	27.929
8	331	10	26.836
8	331	15	29.173
8	331	20	32.2
8	331	30	35.592
8	331	40	39.901
8	331	50	40.385